Effects of Different Core Thickness on The Microhardness of Lithium- Disilicate Glass Ceramic

[1]Nawras Adnan Mohammed, BSc. and [2]Ihab Naffea Yassen, BSc., MSc.
[1, 2]Prosthetic Dental Technologies Department, College of Health and Medical Technology, Middle Technical University, Baghdad, Iraq.
Corresponding author:Nawras Adnan Mohammed
E-mail address dentn92@gmail.com

Received June 02, 2019.
Accepted for publication July 19, 2019.
Published August 10, 2019.

Abstract
Lithium disilicate is the major crystal phase, and be composed of needle-resemble crystals. These crystals are measured from 3 to 6 μm in length. In general, E.max-press properties are very slightly uppermost crystals found in E.max-CAD because of the larger and longer crystals. Due to the materials that have different firing temperatures (820ºC for E.max-press). The objective of this study is to estimate the effect of various thickness on the hardness of a sample prepared by lithium disilicate glass-ceramic material. **Materials and methods** Thirty disc-shaped wax patterns were prepared with three core thickness of (0.5mm, 1mm and 1.5mm). All the specimens fabricated with 10mm in diameter and designed according to the ISO specification 6872. Vickers diamond indenter has widely utilized in this study in accordance with the micro-hardness tester device. **Results** The present data were analyzed statistically using SPSS (V-22). One-way ANOVA and (LSD) test show that the mean values of 0.5mm core thickness was of 800(±120), while the mean value of 1mm core thickness was of 1229 (±139), and that of 1.5mm core thickness was 1117(±221). **Conclusions** the results showed that the lithium disilicate glass-ceramic material had more advanced surface hardness at thickness of 1mm than that of 0.5mm and 1.5mm thickness of the same materials.

Keywords: Glass-ceramic disc, core thickness, dental ceramic, lithium disilicate, microhardness.

Introduction

Dental ceramic materials are metal free and inorganic substance (Rama, 2013). It is fabricated by firing at high temperatures to obtain more acceptable properties. It consisting of oxygen, aluminum, calcium, magnesium, silicon, titanium, and zirconium (Dimitriadis et al, 2006). It is often named inert materials (Wassermann et al, 2006) (Milleding et al, 2002). The main aim of these ceramic researches and developments are to provide firmer and tougher ceramics that structurally dependable in dental usage (K, 2010). All of the properties, especially mechanical properties (hardness, toughness strength) are concerned with each other and affected by material fabrication (Holand, 2008). Lithium disilicate glass-ceramics seem the toughest and strongest among glass-ceramics available. This material have moderate fracture toughness of 2.5-3 MPa and flexural strength of 360-440 MPa (Ma, 2013). It is indicated for anterior and posterior single crowns, for bridges anterior to second premolars and implant superstructures (Farid et al, 2012). There are three primary ways of industrialization for all-ceramic restorations fabricated by casting or with a pressure technique, conventional sintering procedure, and various direct milling technique (Yondem 2011). Hardness is important property in dentistry as it means the resistance to constant surface penetration or indentation. It locates the amount of the impedance to plastic deformation and determined by a force per unit area of indentation (Albakry, 2004). Although for wear and brittle materials, wear occurred because of fracture instead of plastic deformation (Denry, 2010). Ceramics described by their hardness, chemical inertness, refractory nature, biocompatibility (Ghose, 2014; Powers, 2012; Hämmerle, 2008), and susceptibility to brittle fracture (Ho GW, 2011; Lung, 2012). Ceramic copy-veneered fixed prosthesis have been utilized for varied implementation such as anterior and posterior restorations, the final result with this restoration provided strong core with the aesthetics of the veneering porcelains. Although the strength of the all-ceramics totally documented, data on the effect of the varying core thicknesses was little absent (Garber, 1999). Advanced research in dental technology and of modern dental materials had become more in all-ceramic systems. Some of the fabrication techniques are obtainable for manufacturing all-ceramic restorations such as heat pressing sintering, casting infiltration, and machining technique (Dikicier, 2017) (Cattell, 1999). Currently, lithium disilicate glass-ceramics provides rise strength and highly esthetic materials for CAD-CAM and pressing technologies (Lawn, 2011). It is a pressed glass-ceramic ingot (lithium disilicate crystals). These crystals deny the promulgation of microcracks and take part in improving the translucency and esthetic of these restorations (Dickerson, 1999). The chemical basis of this substance is resembling the chemical basis of the IPSE-press [2 (2SiO2 -Li2O)] but the properties are changed by firing processes. Glass ceramic materials show substantially advanced physical properties and higher translucency. E.max-press appear in four levels of opacity HO, (High opaque), HT (High translucent), LT (Low translucent), and MO (Medium opaque). IPse. max lithium disilicate consist of potassium oxide, quartz, phosphor, lithium dioxide, oxide, alumina, and other components. This substance produces a high thermal, shock-resistant glass ceramic as a result of the low thermal expansion that done when its manufactured (Ritter and Rego, 2009), (Tysowsky, 2009).

Materials and methods

Sample preparation

In terms of dental restoration, the procedure was accomplished using a CAD-CAM machine to be efficient and satisfying patients need. Thirty lithium disilicate glass-ceramics of disc-shaped specimens were separated into three groups of 10mm in diameter (n =10), the first group of 0.5mm core thickness, the second of 1mm thickness, and the third group of 1.5mm thickness. All the groups had been designed in accordance to the manufacturer’s instruction. Firstly, the samples designed by sketch-up CAD software with STL extension and CAD-CAM producton method for wax patterns. This to fabricate the lithium disilicate glass-ceramics press to replace the wax patterns with the thickness of 0.5, 1 and 1.5mm (Mohsen, 2011). The wax sample had been transferred to the CAM.

Spruing and investing procedures

The wax pattern was sprued according to manufacturer›s instructions utilize a wire wax sprue of 2.5 mm in diameter. The distance between the wax pattern and the end of the silicon ring was of 10mm and the angle between the sprue and the ring base was of 45°C. The specimens then invested immediately and according to the manufacturer›s instruction using IPS silicon ring. A phosphate-bonded investment material (Bella vest SH) was used. Each 100 g of powder was mixed with 25ml of its special liquid, and allowed to set. After complete investing procedure and final setting, the investment ring was ready for preheating. The investment ring with an opening facing down and positioned in the preheating furnace heated at 850°C for 60 mins. After the preheating cycle had been completed the investment ring was removed from the preheating furnace and the cold lithium disilicate glass-ceramics press ingot was placed into the hot investment ring. Then after final preheating cycle, the investment ring was removed from the furnace immediately.

Finishing and polishing
After complete cooling,the investment ring was divested and all ceramic specimens were immersed in lithium disilicate glass-ceramics invex liquid. This step is important to the proper identification and elimination of the reaction layer, which it may be difficult to see on the pressing step and must be completely removed to ensure an immaculate bond surface for veneering substance, stain, or glaze application. Also, they cleaned in an ultrasonic cleaner unit for 10 mins to accelerate the removal of the investment substance from the ceramic specimens. Each specimen was polished by silicon carbide sandpapers (400 - 600 -1200 grit, respectively), and then sand blasted with 100μm Aluminium oxide (Al_2O_3) at 1 bar pressure to remove the reaction layer completely (Riad et al, 2017). The final dimensions of the discs were of 0.5, 1, and 1.5mm in thickness, and 10mm in diameter (Gonzaga et al, 2008). Now, the lithium disilicate glass-ceramic disc specimens are ready for testing as shown in figure (1).

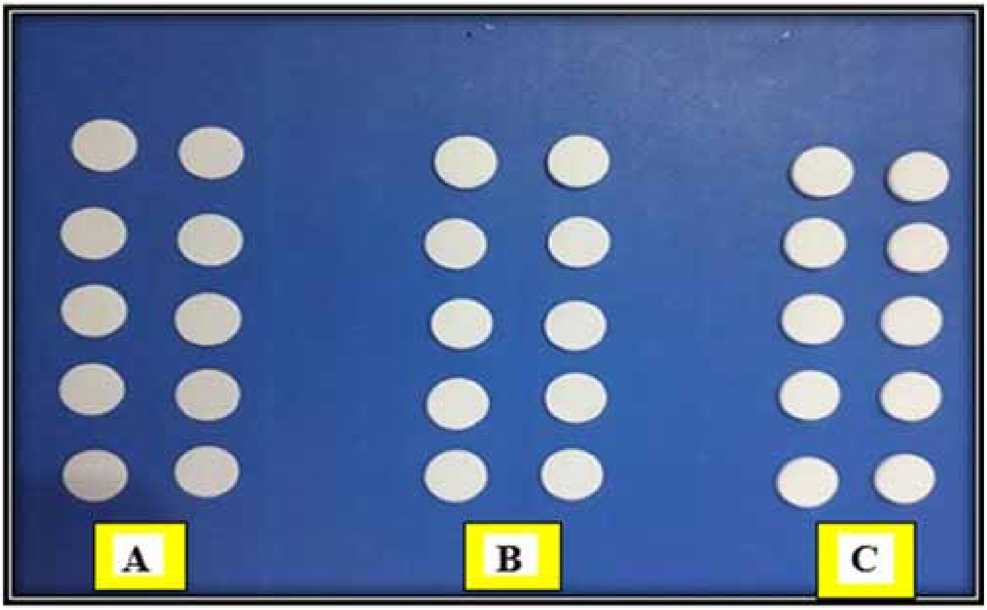

Figure (1): Lithium disilicate glass-ceramics press sample grouping at different thickness A: 0.5mm, B:1mm, C:1.5 mm.

Testing procedure
In dental restoration, there are many researches show that the hardness value of ceramic material is higher than a human being enamel and several metal alloys. After that, the significance of measuring hardness in dental material is that it delineates the abrasiveness of a material to which the natural dentition may be submitted (Al-bakry, 2003). A Vickers diamond pyramid indenter test was utilized for determining the hardness of small diameter specimen (VHN) (Midelling, 2002, Anusavice, 1996). The procedure involved all the requirements by the standard test method for the microhardness of dental ceramic materials. Hardness measurements were made with a Diriment microhardness tester (Leitz Gm bH, Wetzlar, Germany). Three indentations were produced for each specimen under a load of 9.8N , a diamond indenter was used to provide the micro-hardness value and with the help of Vickers hardness tester (Chuenarrom, Benjakul et al, 2009). Once the indentations were performed, the values were obtained in the Vickers hardness number.

Statistical Analysis
In this study, the data analyzed using SPSS (V-22). LSD test was used at a confedence level of 95% and a significant P-Value of ($p \le 0.05$).

Results
Table (1) and figure (2) showed the results concerning the means and standard deviations of the ceramics micro-hardness of the lithium disilicate glass ceramic material. There was statisticaly significant differences among the tested groups ($p \le 0.01$). The mean values of 0.5mm, 1mm, and 1.5mm core thickness was of 800 (±120), 1229 (±139), and 1117 (±221), respectively.

Table (1): LSD test showing the micro-hardness value for all IPSE-Max press tested groups.

(I) Material Z	(J) Material Z	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
E-Max 0.5mm	E-Max 1mm	-428	43	.000*	-514	-343
	E-Max 1.5mm	-317	43	.000*	-402	-231
E-Max 1mm	E-Max 1.5mm	112	43	.011*	26	197

(*) S: Sig. at $p<0.05$.

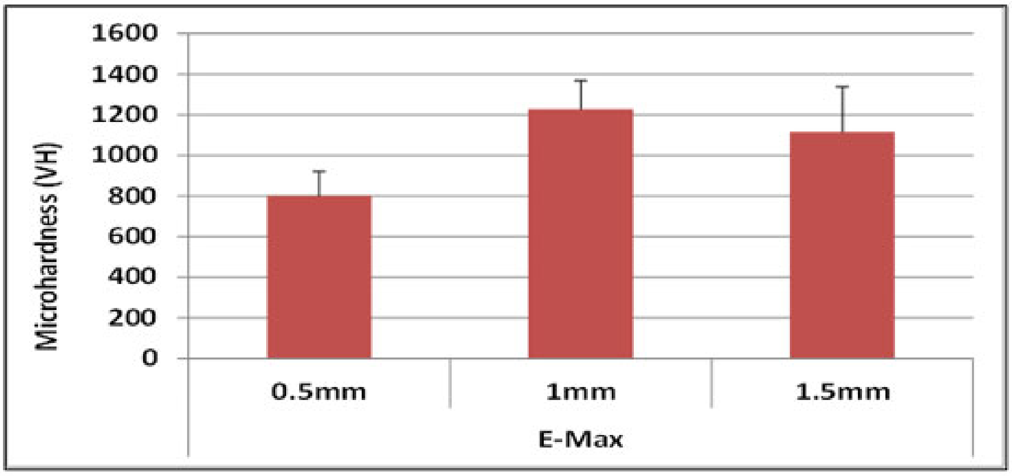

Figure (2): Bar chart showing the hardness of IPSE-Max press at different thickness.

Discussion

Nowadays, the utilizing of all-ceramic materials have been increasingly common to restorative dentistry. Currently, the enhancement of appearance is widely demanded. The development of novel all-ceramic systems due to needing for aesthetic materials in dentistry. It is described by improving high biocompatibility and esthetic specification. Also, lithium disilicate glass-ceramics press materials have acceptable color stability, high strength, and high resistance to wear (Gonzaga et al, 2008). A numerical of all-ceramic systems are recently obtainable for dental restorations. Among these, it is one of the most common material because of good marginal and mechanical fit properties, and the low porosity when compared to widely used feldspathic porcelains (Milleding et al, 2002). Lithium disilicate glass-ceramics as an innovative material provides the total all-ceramics usage range from fine veneers to 10 units FPDs. They offer high esthetic and strength materials for the press and the CAD-CAM technologies, (Milleding et al, 2002). Therefore, it was chosen in this study due to their superior mechanical properties. Indentation hardness testing is a common method of examining the mechanical properties of a very small in diameter sample. Lithium disilicate glass-ceramics press were chosen as being recommended for utilizing in posterior crowns because of the improved mechanical properties. Several properties of a material are concerned to its hardness as strength, ductility and proportional limit (Milleding et al, 2002) (Anusavice, 1996). The result of the present study explains that lithium disilicate glass-ceramic material showed significantly higher Vickers›s hardness mean values (VHN). The mean value of the micro surface hardness for the group of 0.5mm core thickness with 800 (±120) was lower than that of the 1.5mm with 1117 (±221) mean value which in turn lower than that of 1mm core thickness of 1229 (±139) mean value. This may be related to the composition of Ipse max press material which provide a high thermal, shock-resistant glass ceramic as a result of low thermal expansion that done when it is completed. The pressing of lithium disilicate glass ceramic has a very high plastic deformation procedure that can arrange the crystals in an alignment parallel to pressing direction; this could be shared to increasing the VHN. The lithium disilicate crystals deny the propagation of microcracks and contribute to increasing the esthetic translucency of the restorations. This may be agreed with (Albakry, 2003) (Bestoon Mohamme, 2015). They studying the Ipse max press specimens of different thickness and the results show that the group of 1mm thickness was the best as it provides acceptable esthetics and translucency under all-ceramic restorations. Moreover, it could act as conservative to tooth structure and provides enough space for the outer layer for veneer ceramic material. This may agree with (Riad et al, 2017). Therefore, lithium disilicate cores should be fabricated at 1mm thickness with a minimum thickness of 0.8 mm and as recommended by (Farid et al, 2012)

Conclusions

Within the study limitation, the results concluded that the lithium disilicate glass-ceramic material displays a higher surface hardness for thickness with 1mm than that of 0.5mm and 1.5mm thickness of the same materials.

Conflict of interest

We are the author's Nawras Adnan Mohammed and Assist. Prof. Ihab Naffea Yassin, stated that the manuscript for this paper is original, and it has not been published previously, it is part of my MSc dissertation, and is not under consideration for publication elsewhere, and that the final version has been seen and approved by all authors.

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